CLAIMS:

What is claimed is:

1. A system for detecting movement of a substrate, system comprising:

a first signal acquisition means for acquiring a first substantially sinusoidal signal related to the position of the substrate;

a second signal acquisition means for acquiring a second substantially sinusoidal signal related to the position of the substrate that is substantially 90 degrees out of phase with the first substantially sinusoidal signal;

a signal selection means for:

comparing the first substantially sinusoidal signal and the second substantially sinusoidal signal,

selecting the signal with the lesser instantaneous magnitude as the primary signal,

selecting the signal with the greater instantaneous magnitude as the secondary signal, and

producing a reference signal indicating whether the first substantially sinusoidal signal or the second substantially sinusoidal signal was selected as the primary signal;

a phase angle converter means for converting the primary signal into a phase angle signal; and

an angular movement detection means for:

determining angular movement over time based on the value of the phase angle signal over time, and

producing a corresponding angular movement signal.

2. The system of claim 1, wherein said phase angle converter means comprises:

a signal normalizing means for producing a normalized position signal by mapping the primary signal to a corresponding substantially sinusoidal signal with a known amplitude;

a phase angle lookup means for converting the normalized position signal into an uncorrected phase angle signal corresponding to the instantaneous phase angle of the normalized position signal; and

a phase translation means for producing a phase angle signal by correcting the phase angle signal based on the values of the secondary signal and the reference signal.

3. The system of claim 2, wherein said angular movement detection means comprises:

a phase register means for storing the corrected phase angle signal and outputting a previous iteration corrected phase angle signal equal to the corrected phase angle signal; and

a phase subtractor means for producing an uncorrected angular movement signal by subtracting the previous iteration corrected phase angle signal from the corrected phase angle signal.

4. The system claim 3, wherein said angular movement detection means further comprises:

an overflow corrector means for correcting the uncorrected angular movement signal in the case of an overflow or underflow and producing the angular movement signal.

5. The system of claim 4, wherein:

said first signal acquisition means comprises a plurality of transducers; and

said second signal acquisition means comprises a plurality of transducers.

6. The system of claim 4 further comprising:

a traditional quadrature output emulating means for converting the angular movement signal into traditional quadrature output signals.

7. The system of claim 4, wherein said signal selection means is implemented in software in a digital controller.

8. The system of claim 7, wherein the digital controller is a MSP430 digital controller.

9. The system of claim 4, wherein said phase angle lookup means computes the instantaneous uncorrected phase angle of the normalized position signal using the formula:

$$uncorrected\ phase\ angle = \left\lfloor \frac{resolution}{360^\circ} \times \arccos\left(\frac{normalized\ position\ signal}{known\ amplitude} \right) \right\rfloor$$

where the value of "resolution" is a predefined constant and the value of "known amplitude" is a predefined constant.

10. The system of claim 4, wherein said phase angle lookup means computes the instantaneous phase angle of the normalized position signal using a lookup table.

11. The system of claim 10, wherein the resolution is 32.

12. The system of claim 4, wherein said phase angle lookup means is implemented in software in a digital controller.

13. The system of claim 12, wherein said digital controller is a MSP430 digital controller.

14. The system of claim 4, wherein, in the case where said signal selections means selects the first substantially sinusoidal signal as the primary signal, said phase translation means corrects the phase angle signal by:

performing no correction if the secondary output signal is greater than zero, or using the equation:

phase angle signal = resolution – 1 – uncorrected phase angle signal

if the secondary signal is less than zero,

and where the value of resolution is a predefined constant.

15. The system of claim 14, wherein, in the case where said signal selections means selects the second substantially sinusoidal signal as the primary signal, said phase translation means corrects the phase angle signal by:

using the equation:

$$phase\ \ angle\ signal = \left(\text{uncorrected phase angle} + \frac{\text{resolution}}{4} \right) \%\ \text{resolution}$$

if the secondary signal is less than zero, or

using the equation

$$phase\ \ angle\ signal = \left(\left(resolution - 1 - uncorrected\ phase\ \ angle \right) + \frac{\text{resolution}}{4} \right) \%\ \text{resolution}$$

if the secondary signal is greater than zero,
and where the value of resolution is a predefined constant.

16. The system of claim 15, wherein the resolution is 32.

17. The system of claim 15, wherein said phase translation means is implemented in software in a digital controller.

18. The system of claim 17, wherein said digital controller is a MSP430 digital controller.

19. The system of claim 4, wherein said phase register means is implemented in software in a digital controller.

20. The system of claim 19, wherein said digital controller is a MSP430 digital controller.

21. The system of claim 4, wherein said phase subtractor means is implemented in software in a digital controller.

22. The system of claim 21, wherein said digital controller is a MSP430 digital controller.

23. The system of claim 4, wherein the overflow corrector means corrects the uncorrected angular movement output signal:
by using the equation:

$$\text{angular movement} = \text{uncorrected angular movement} - \text{resolution},$$

if uncorrected angular movement output signal > resolution/2;

by using the equation:

$$\text{angular movement} = \text{uncorrected angular movement} + \text{resolution},$$

if uncorrected angular movement output signal < -resolution/2; or

by using the equation:

$$\text{angular movement} = \text{uncorrected angular movement},$$

if resolution/2 $\geq$ uncorrected angular movement output signal $\geq$ -resolution/2;

where the value of resolution is a predefined constant.

24. The system of claim 23, wherein the resolution is 32.

25. The system of claim 23, wherein said overflow corrector means is implemented in software in a digital controller.

26. The system of claim 25, wherein said digital controller is a MSP430 digital controller.

27. The system of claim 4, wherein said traditional quadrature output emulating means outputs at least three traditional quadrature output signals.

28. The of claim 27, wherein said traditional quadrature output means is represented by a simple finite state machine.

29. The system of claim 28, wherein said traditional quadrature output emulating means is implemented in software in a digital controller.

30. The system of claim 29, wherein said digital controller is a MSP430 digital controller.

31. The system of claim 4, wherein at least one of said first transducer, said second transducer, said third transducer, and said fourth transducer is a Hall-effect sensor.

32. The system of claim 2, wherein the signal normalizing means:

computes the amplitude of the primary signal, and

maps the primary signal to a corresponding sinusoidal signal with known amplitude.

33. The system of claim 2, wherein said signal normalizing means computes the amplitude of the primary signal using the formula:

$$\text{amplitude} = \sqrt{p^2 + s^2}$$

where "p" represents the instantaneous magnitude of the primary signal and "s" represents the instantaneous magnitude of the secondary signal.

34. The system of claim 2, wherein said signal normalizing means determines the amplitude of the primary signal using a lookup table.

35. The system of claim 2, wherein said signal normalizing means maps the primary output signal to a corresponding sinusoidal signal with a known amplitude using the formula:

$$\text{normalized postion signal} = \left\lfloor \frac{\text{known amplitude}}{\text{amplitude}} \times 2^{10} \right\rfloor \times p \times 2^{-10}.$$

36. The system for sensing position and/or displacement of a moving substrate of claim 35, wherein the known amplitude is 2048.

37. The system of claim 36, wherein said signal normalizing means is implemented in software in a digital controller.

38. The system of claim 37, wherein said digital controller is a MSP430 digital controller.

39. The system of claim 2, wherein said signal normalizing means computes:

$$\left\lfloor \frac{\text{known amplitude}}{\text{amplitude}} \times 2^{10} \right\rfloor$$

using a lookup table.

40. The system of claim 2, wherein said signal normalizing means executes a right shift operation to compute the $\times 2^{-10}$ operation.

41. The claim 1, wherein

said substrate comprising a plurality of equally-spaced bands of magnetic material disposed circumferentially around the substrate;

said first signal acquisition means comprises:

a plurality of transducers including at least:

a first transducer mounted proximately to the substrate such that when the substrate moves said plurality of bands of magnetic material disposed circumferentially around said the substrate pass said first transducer thereby generating a substantially sinusoidal first transducer output signal; and

a second transducer mounted proximately to said substrate such that when the substrate moves said plurality of bands of magnetic material disposed circumferentially around said substrate pass said second transducer thereby generating a substantially sinusoidal second transducer output signal;

wherein said first transducer and said second transducer are:

positioned linearly with respect to each other, and

spaced such that the distance between said first transducer and said second transducer is substantially equal to one-half of the distance between two adjacent bands of magnetic material disposed circumferentially around said substrate such that the substantially sinusoidal first transducer output signal is substantially 180 degrees out of phase with the substantially sinusoidal second transducer output signal; and

said second signal acquisition means comprises:

a plurality of transducers including at least:

a third transducer mounted proximately to said substrate such that when said substrate moves said plurality of bands of magnetic material disposed circumferentially around said substrate pass said third transducer

thereby generating a substantially sinusoidal third transducer output signal, and

a fourth transducer mounted proximately to said substrate such that when said substrate moves said plurality of bands of magnetic material disposed circumferentially around said substrate pass said fourth transducer thereby generating a substantially sinusoidal fourth transducer output signal,

wherein said third transducer and said fourth transducer are:

positioned linearly with respect to each other as well as with respect to said first transducer and said second transducer such that said third transducer is located between said first transducer and said second transducer, and

spaced such that:

the distance between said third transducer and said fourth transducer is substantially equal to one-half of the distance between two adjacent bands of magnetic material disposed circumferentially around said substrate such that the substantially sinusoidal third transducer output signal is substantially 180 degrees out of phase with the substantially sinusoidal fourth transducer output signal,

the distance between said third transducer and said first transducer is substantially equal to one-quarter of the distance between two adjacent bands of magnetic material disposed circumferentially around said substrate,

the distance between said third transducer and said second transducer is substantially equal to one-quarter of the distance between two adjacent bands of magnetic material disposed circumferentially around said substrate,

the distance between said fourth transducer and said first transducer is substantially equal to three-quarters of the distance between two adjacent bands of magnetic material disposed circumferentially around said substrate, and

the distance between said fourth transducer and said second transducer is substantially equal to one-quarter of the distance between two adjacent bands of magnetic material disposed circumferentially around said substrate.

42. The system of claim 41, wherein:
said first signal acquisition means further comprises:

a first signal combining means for producing a first combined signal by subtracting the second transducer output signal from the first transducer output signal and amplifying the resulting signal,

a first analog-to-digital converter for producing the first substantially sinusoidal signal related to the position of said substrate by converting a first calibrated signal into a digital signal,

a first averaging means for producing a first digital error signal, by:

performing a time-average of the first substantially sinusoidal signal related to the position of said substrate, and

subtracting the time-average of the first substantially sinusoidal signal related to the position of said substrate from the value of the direct current offset required by the first analog-to-digital converter,

a first digital-to-analog converter for converting the first digital error signal into a first analog error signal,

a first subtractor means for producing the first calibrated signal by subtracting the first analog error signal from the first combined signal; and
said second signal acquisition means further comprises:

a second signal combining means for producing a second combined signal by subtracting the fourth transducer output signal from the third transducer output signal and amplifying the resulting signal,

a second analog-to-digital converter for producing the second substantially sinusoidal signal related to the position of said substrate by converting a second calibrated signal into a corresponding digital signal,

a second averaging means for producing a second digital error signal by:

performing a time-average of the second substantially sinusoidal signal related to the position of said substrate, and

subtracting the time-average of the second substantially sinusoidal signal related to the position of said substrate from the value of the direct current offset required by said second analog-to-digital converter,

a second digital-to-analog converter for converting the second digital error signal into a second analog error signal, and

a second subtractor means for producing the second calibrated signal by subtracting the second analog error signal from the second combined signal.

43. The system of claim 1, wherein:
said first signal acquisition means further comprises:

a first signal combining means for producing the first substantially sinusoidal signal related to the position of said substrate by subtracting the second transducer output signal from the first transducer output signal and amplifying the resulting signal; and

said second signal acquisition means further comprises:

a second signal combining means for producing the second substantially sinusoidal signal related to the position of said substrate by subtracting the fourth transducer output signal from the third transducer output signal and amplifying the resulting signal.

44. The system of claim 43, wherein:
said first signal combining means is a differential amplifier, and
said second signal combining means is a differential amplifier.

45. The system of claim 1, wherein:
said first signal acquisition means further comprises:

a first signal combining means for producing a first combined signal by subtracting the second transducer output signal from the first transducer output signal and amplifying the resulting signal, and

a first analog-to-digital converter for producing the first substantially sinusoidal signal related to the position of said substrate by converting the first combined signal into a corresponding digital signal; and

said second signal acquisition means further comprises:

a second signal combining means for producing a second combined signal by subtracting the fourth transducer output signal from the third transducer output signal and amplifying the resulting signal; and

a second analog-to-digital converter for producing the second substantially sinusoidal signal related to the position of said substrate by converting the second combined signal into a corresponding digital signal.

46. The system for sensing position and/or displacement of a moving substrate of claim 45, wherein:

said first signal combining means is a differential amplifier, and

said second signal combining means is a differential amplifier.

47. The system of claim 45, wherein:

said first signal combining means is a differential amplifier, and

said second signal combining means is a differential amplifier.

48. The system of claim 1, wherein said moving substrate comprises a ram, target, or piston.

49. The system of claim 1, said moving substrate comprising a plurality of equally-spaced bands of magnetic material disposed circumferentially around said substrate.

50. The system of claim 49, wherein said moving substrate comprises a ram, target or piston.

51. The system of claim 1, wherein said moving substrate comprises an optical encoder.

52. The system of claim 51, wherein said optical encoder comprises an encoder wheel.

53. The system of claim 52, wherein said optical encoder wheel comprises apertures wherein at least one of said first signal acquisition means and said second signal acquisition means comprises an optical detector.

54. The system of claim 53, wherein said optical detector comprises a photo diode.

55. A method for detecting movement of a moving substrate, comprising:

acquiring a first substantially sinusoidal signal related to the position of said substrate;

acquiring a second substantially sinusoidal signal related to the position of said substrate that is substantially 90 degrees out of phase with the first substantially sinusoidal signal;

comparing the first substantially sinusoidal signal and the second substantially sinusoidal signal, selecting the signal with the lesser instantaneous magnitude as the primary signal, selecting the signal with the greater instantaneous magnitude as the secondary signal, and producing a reference signal indicating whether the first substantially sinusoidal signal or the second substantially sinusoidal signal was selected as the primary signal;

converting the primary signal into a phase angle signal; and

determining angular movement over time and producing a corresponding angular movement signal.

56. The method of claim 55, wherein converting the primary signal into a phase angle signal comprises:

producing a normalized position signal by mapping the primary signal to a corresponding substantially sinusoidal signal with a known amplitude;

converting the normalized position signal into an uncorrected phase angle signal corresponding to the instantaneous phase angle of the normalized position signal; and

producing a phase angle signal by correcting the uncorrected phase angle signal based on the values of the secondary signal and the reference signal.

57. The method of claim 56, wherein determining angular movement over time and producing a corresponding angular movement output signal comprises:

storing the phase angle signal and outputting a previous iteration phase angle signal equal to the phase angle signal;

subtracting the previous iteration phase angle signal from the phase angle output signal and producing an uncorrected angular movement signal; and

producing the angular movement signal by correcting the uncorrected angular movement signal in the case of an overflow or underflow.

58. The method of claim 57, wherein:

said substrate comprising a plurality of equally-spaced bands of magnetic material disposed circumferentially around said substrate;

acquiring the first substantially sinusoidal signal related to the position of said substrate comprises using a plurality of transducers including at least:

a first transducer mounted proximately to said substrate such that when said substrate moves said plurality of bands of magnetic material disposed circumferentially around said substrate pass said first transducer thereby generating a substantially sinusoidal first transducer output signal; and

a second transducer mounted proximately to said substrate such that when said substrate moves said plurality of bands of magnetic material disposed circumferentially around said substrate pass said second transducer thereby generating a substantially sinusoidal second transducer output signal;

wherein said first transducer and said second transducer are:

positioned linearly with respect to each other and

spaced such that the distance between said first transducer and said second transducer is substantially equal to one-half of the distance between two adjacent bands of magnetic material disposed circumferentially around said substrate such that the substantially sinusoidal first transducer output signal is substantially 180 degrees out of phase with the substantially sinusoidal second transducer output signal; and

acquiring the second substantially sinusoidal signal related to the position of said substrate comprises using a plurality of transducers including at least:

a third transducer mounted proximately to said substrate such that when said substrate moves said plurality of bands of magnetic material disposed circumferentially around said substrate pass said third transducer thereby generating a substantially sinusoidal third transducer output signal, and

a fourth transducer mounted proximately to said substrate such that when said substrate moves said plurality of bands of magnetic material disposed circumferentially around said substrate pass said fourth transducer thereby generating a substantially sinusoidal fourth transducer output signal,

wherein said third transducer and said fourth transducer are:

positioned linearly with respect to each other as well as with respect to said first transducer and said second transducer such that said third transducer is located between said first transducer and said second transducer, and

spaced such that:

the distance between said third transducer and said fourth transducer is substantially equal to one-half of the distance between two adjacent bands of magnetic material disposed circumferentially around said substrate such that the substantially sinusoidal third transducer output signal is substantially 180 degrees out of phase with the substantially sinusoidal fourth transducer output signal.

the distance between said third transducer and said first transducer is substantially equal to one-quarter of the distance between two adjacent bands of magnetic material disposed circumferentially around said substrate,

the distance between said third transducer and said second transducer is substantially equal to one-quarter of the distance between two adjacent bands of magnetic material disposed circumferentially around said substrate,

the distance between said fourth transducer and said first transducer is substantially equal to three-quarters of the distance

between two adjacent bands of magnetic material disposed circumferentially around said substrate, and

the distance between said fourth transducer and said second transducer is substantially equal to one-quarter of the distance between two adjacent bands of magnetic material disposed circumferentially around said substrate.

59. The method of claim 58, wherein:

acquiring the first substantially sinusoidal signal related to the position of said substrate further comprises:

producing the first substantially sinusoidal signal related to the position of said substrate by subtracting the second transducer output signal from the first transducer output signal and amplifying the resulting signal; and

acquiring the second substantially sinusoidal signal related to the position of said substrate further comprises:

producing the second substantially sinusoidal signal related to the position of said substrate by subtracting the fourth transducer output signal from the third transducer output signal and amplifying the resulting signal.

60. The method of claim 59, wherein:

subtracting the second transducer output signal from the first transducer output signal and amplifying the resulting signal is accomplished using a first differential amplifier, and

subtracting the fourth transducer output signal from the third transducer output signal and amplifying the resulting signal is accomplished using a second differential amplifier.

61. The method of claim 58, wherein:

acquiring the first substantially sinusoidal signal related to the position of said substrate further comprises:

producing a first combined signal by subtracting the second transducer output signal from the first transducer output signal and amplifying the resulting signal, and

producing the first substantially sinusoidal signal related to the position of said substrate by converting the first combined signal into a corresponding digital signal; and

acquiring the second substantially sinusoidal signal related to the position of said substrate further comprises

producing a second combined signal by subtracting the fourth transducer output signal from the third transducer output signal and amplifying the resulting signal; and

producing the second substantially sinusoidal signal related to the position of said substrate by converting the second combined signal into a corresponding digital signal.

62. The method of claim 61, wherein:

subtracting the second transducer output signal from the first transducer output signal and amplifying the resulting signal is accomplished using a first differential amplifier, and

subtracting the fourth transducer output signal from the third transducer output signal and amplifying the resulting signal is accomplished using a second differential amplifier.

63. The method of claim 58, wherein:

acquiring the first substantially sinusoidal signal related to the position of said substrate comprises:

producing a first combined signal by subtracting the second transducer output signal from the first transducer output signal and amplifying the resulting signal,

producing a first digital error output signal,

converting the first digital error output signal into a first analog error signal,

producing a first calibrated signal by subtracting the first analog error signal from the first combined signal, and

producing the first substantially sinusoidal signal related to the position of said substrate by converting the first calibrated signal into a corresponding digital signal; and

acquiring the second substantially sinusoidal signal related to the position of said substrate comprises

producing a second combined signal by subtracting the fourth transducer output signal from the third transducer output signal and amplifying the resulting signal,

producing a second digital error output signal,

converting the second digital error output signal into a second analog error signal,

producing a second calibrated signal by subtracting the second analog error signal from the second combined signal, and

producing the second substantially sinusoidal signal related to the position of said substrate by converting the second calibrated signal into a corresponding digital signal.

64. The method of claim 63, wherein:

producing the first digital error signal comprises:

performing a time-average of the first substantially sinusoidal signal related to the position of said substrate and subtracting it from the value of the direct current offset required by said first analog-to-digital converter; and

producing the second digital error signal comprises:

performing a time-average of the second substantially sinusoidal signal related to the position of said substrate and subtracting it from the value of the direct current offset required by said second analog-to-digital converter.

65. The method of claim 58, wherein:

subtracting the second transducer output signal from the first transducer output signal and amplifying the resulting signal is accomplished using a first differential amplifier, and

subtracting the fourth transducer output signal from the third transducer output signal and amplifying the resulting signal is accomplished using a second differential amplifier.

66. The method of claim 58, wherein said digital controller is a MSP430 digital controller.

67. The method of claim 57, wherein comparing the first substantially sinusoidal signal and the second substantially sinusoidal signal, selecting the signal with the lesser instantaneous magnitude as the primary signal, selecting the signal with the greater instantaneous magnitude as the secondary signal, and producing a reference signal is implemented in software in a digital controller.

68. The method of claim 67, wherein said digital controller is a MSP430 digital controller.

69. The method of claim 57, wherein storing the phase angle signal and outputting a previous iteration phase angle signal equal to the phase angle signal is implemented in software in a digital controller.

70. The method of claim 69, wherein said digital controller is a MSP430 digital controller.

71. The method of claim 57, wherein subtracting the previous iteration phase angle signal from the phase angle signal and producing an uncorrected angular movement signal is implemented in software in a digital controller.

72. The method of claim 71, wherein said digital controller is a MSP430 digital controller.

73. The method of claim 72, wherein the resolution is 32.

74. The method of claim 72, wherein correcting the uncorrected angular movement output signal is implemented in software in a digital controller.

75. The method of claim 74, wherein said digital controller is a MSP430 digital controller.

76. The method of claim 56, wherein producing a normalized position signal by mapping the primary signal to a corresponding substantially sinusoidal signal with a known amplitude comprises:

computing the amplitude of the primary signal, and

mapping the primary signal to a corresponding sinusoidal signal with known amplitude.

77. The method of claim 76, wherein computing the amplitude of the primary signal is accomplished using the formula:

$$\text{amplitude} = \sqrt{p^2 + s^2}$$

where "p" represents the instantaneous magnitude of the primary signal and "s" represents the instantaneous magnitude of the secondary signal.

78. The method of claim 76, wherein determining the amplitude of the primary signal is accomplished using a lookup table.

79. The method claim 76, wherein mapping the primary signal to a corresponding sinusoidal signal with a known amplitude is accomplished using the formula:

$$\text{normalized postion signal} = \left\lfloor \frac{\text{known amplitude}}{\text{amplitude}} \times 2^{10} \right\rfloor \times p \times 2^{-10}.$$

80. The method of claim 79, wherein computing:

$$\left\lfloor \frac{\text{known amplitude}}{\text{amplitude}} \times 2^{10} \right\rfloor$$

is accomplished using a lookup table.

81. The method of claim 80, wherein computing the $\times 2^{-10}$ operation is accomplished by using a right shift operation.

82. The method of claim 81, wherein the known amplitude is 2048.

83. The method of claim 76, wherein producing a normalized position signal by mapping the primary signal to a corresponding substantially sinusoidal signal with a known amplitude is implemented in software in a digital controller.

84. The method of claim 56, wherein computing the instantaneous uncorrected phase angle of the normalized position signal is accomplished using the formula:

$$\textit{uncorrected phase angle} = \left\lfloor \frac{\textit{resolution}}{360^\circ} \times \arccos\left(\frac{\textit{normalized position signal}}{\textit{known amplitude}} \right) \right\rfloor$$

where the value of "resolution" is a predefined constant and the value of "known amplitude" is a predefined constant.

85. The method of claim 56, wherein computing the instantaneous uncorrected phase angle of the normalized position signal is accomplished using a lookup table.

86. The method of claim 85, wherein the resolution is 32.

87. The method of claim 56, wherein computing the instantaneous uncorrected phase angle of the normalized position signal is implemented in software in a digital controller.

88. The method of claim 87, wherein said digital controller is a MSP430 digital controller.

89. The method of claim 56, wherein, in the case where the first substantially sinusoidal signal is selected as the primary signal, correcting the uncorrected phase angle signal comprises:

performing no correction if the secondary output signal is greater than zero, or using the equation:

phase angle signal = resolution – 1 – uncorrected phase angle signal

if the secondary output signal is less than zero,

and where there value of resolution is a predefined constant.

90. The method of claim 89, wherein, in the case where the second substantially sinusoidal signal is selected as the primary signal, correcting the uncorrected phase angle signal comprises:

using the equation:

$$phase\quad angle\ signal = \left(\text{uncorrected phase angle} + \frac{\text{resolution}}{4}\right)\%\ \text{resolution}$$

if the secondary output signal is less than zero, or

using the equation:

$$phase\quad angle\ signal = \left((resolution - 1 - uncorrected\ phase\quad angle) + \frac{\text{resolution}}{4}\right)\%\ \text{resolution}$$

if the secondary output signal is greater than zero,

and where the value of resolution is a predefined constant.

91. The method of claim 90, wherein the resolution is 32.

92. The method of claim 90, wherein correcting the uncorrected phase angle signal is implemented in software in a digital controller.

93. The method of claim 92, wherein said digital controller is a MSP430 digital controller.

94. The method of claim 56, wherein correcting the uncorrected angular movement signal comprises:

using the equation:

angular movement = uncorrected angular movement – resolution

if uncorrected angular movement signal > resolution/2;

using the equation:

angular movement = uncorrected angular movement + resolution

if uncorrected angular movement output signal < -resolution/2; or

using the equation:

angular movement = uncorrected angular movement

if resolution/2 $\geq$ uncorrected angular movement $\geq$ -resolution/2;

where the value of resolution is a predefined constant.

95. The method of claim 56, wherein at least one of said first transducer, second transducer, third transducer, and fourth transducer is a Hall-effect sensor.

96. The method of claim 55 further comprising:

converting the angular movement signal into a plurality of traditional quadrature output signals.

97. The method of claim 96, wherein converting the angular movement signal into a plurality of traditional quadrature output signals comprises outputting at least three traditional quadrature output signals.

98. The method of claim 97, wherein the plurality of traditional quadrature output means is represented by a simple finite state machine.

99. The method of claim 98, wherein said simple finite state machine is implemented in software in a digital controller.

100. The method of claim 99, wherein said digital controller is a MSP43 0 digital controller.

101. The method of claim 55, wherein said moving substrate comprises a ram, target, or piston.

102. The method of claim 55, said moving substrate comprising a plurality of equally-spaced bands of magnetic material disposed circumferentially around said substrate.

103. The method of claim 102, wherein said moving substrate comprises a target, ram or piston.

104. The method of claim 55, wherein said moving substrate comprises an optical encoder.

105. The method of claim 104, wherein said optical encoder comprises an encoder wheel.

106. The method of claim 105, wherein said optical encoder wheel comprises apertures and wherein:

said acquiring said first substantially sinusoidal signal comprises optically detecting and/or

said acquiring second substantially sinusoidal signal acquisition comprises optically detecting.

107. The method of claim 106, wherein said optical detection is performed by an optical detector.

108. The method of claim 107, wherein said optical detector comprises a photo diode.